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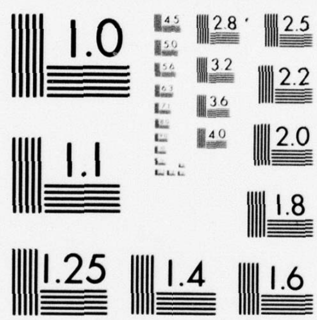

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RADC-TR-79-2
Final Technical Report
February 1979

SCANNING CURSOR TECHNIQUES II

RCA/Advanced Technology Laboratories

G. W. Hunka

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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The objective of the program was to convert a successfully demonstrated transmissive scanning cursor to operate in a reflective mode, for use on opaque cartographic manuscripts. The transmissive cursor, employing a linear photosensitive array for feature sensing, was designed for aided-track tracing of backlighted material, and provides automatic corrections for tracing errors when digitizing cartographic materials.

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Results of investigations into means for providing an internal source of illumination for a scanning cursor are discussed. A fiber optic illumination scheme, which was implemented for test, is the recommended approach. Its major advantage is in providing a good source of light while avoiding heating effects that would tend to degrade the correctional ability of the cursor. The light source itself is controllable in intensity and is remotely located. The fiber optic illumination can easily be incorporated into a compact scanning cursor based on the design of the transmissive unit.

Using the fiber optic source, array outputs for a variety of cartographic materials were observed, and electronic compensation was designed and tested to account for changes in average levels due to background color differences. The automatic balance amplifier, constructed as a result of these tests, is shown to be an effective means for suppressing the effects of background changes, while selectively amplifying only the detected feature.

The action of the amplifier is to automatically maintain a constant average output in the presence of input variations. A feedback loop generates balance voltages to adjust the dc operating point for amplifying the detected signal while keeping the background at a saturated level. This self-balancing feature also provides a range of tolerance to variations of source brightness.

It was demonstrated that adequate signal-to-noise ratios are obtained for unambiguous detection of 4-mil features against backgrounds displaying spatial noise resulting from half-tone patterns used in some color printing processes. A wide variety of representative cartographic manuscripts were successfully tested.

In addition to tests on printed material, the reflective scanning cursor was also used on graphic features drawn with colored pencils and ball-point inks commonly employed in the map digitizing process. Except for lines in the red color region, these inputs were effectively detected and processed by the scanning cursor system. One factor influencing detection of red features is the relative transparency of the beam splitter in the optical system at longer wavelengths. Beam splitter coatings for increasing the red spectrum reflectance are to be specified for future units to improve detection capability.

PREFACE

Work performed and reported herein was supported by RADC Contract No. F30602-77-C-0243.

This document is the Final Report of this contract, and describes the primary program objective, the modification of an exploratory development-model cursor (constructed under RADC Contract No. F30602-74-C-0318) to incorporate a source of illumination for use on opaque digitizing tables. The report is concerned with the choice of the illumination source, determination of feature detection capability on representative opaque cartographic materials, the isolation of problem areas peculiar to reflective mode operation, and development of techniques to overcome or avoid such problems as they become defined. Proposed methods were also investigated for incorporating the elements required for reflective operation within an advanced developmental cursor.

As a part of this contract, a computer-video processor interface connector was fabricated to make the electronic package of the feasibility model cursor compatible for operation with a Hewlett-Packard 2105A, MX-series minicomputer. This interface was exercised by transfer of data through the interface, and functioned properly. Lacking a Gradicon digitizing table and station IMLAC video terminal, full scale dynamic testing was not possible.

Engineering Services were also provided under this contract in support of field engineering evaluation of the Transmissive Scanning Cursor (TSC) system at the Defense Mapping Agency Hydrographic Center (DMAHC), Suitland, MD. This TSC was developed under RADC Contract No. F30602-76-C-0443, Scanning Cursor Device.

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EVALUATION

This report addresses an area supporting an integrated program designed to introduce automation into the cartographic processes. It directly addresses the needs of TPO thrust R2D to develop an increased capability of converting analog cartographic source material into a digital record.

A scanning cursor simplifies a tedious and error prone digitizing procedure by allowing an operator to make small digitizing errors which are automatically computer corrected. Results are an increased overall conversion rate while maintaining required accuracy. Incorporating a light source allows the scanning cursor to be used in the conversion of opaque cartographic materials.

Stanley Damon

STANLEY DAMON
Project Engineer

Section I

INTRODUCTION

Under RADC Contract F30602-76-C-0443, RCA built and tested a Transmissive Scanning Cursor (TSC) designed to interface with a Gradicon digitizing table. The TSC system was successfully interfaced at the Defense Mapping Agency Hydrographic Center (DMAHC) with the table and the Lineal Input System (LIS) in use at the facility, and evaluated at an engineering level. Results of the evaluation indicated that use of the TSC system produced more accurate traces than possible in the normal manual tracing mode, at the same time increasing the efficiency of the cartographic digitizing process. These results are presented in the Final Report issued under that program.

The Gradicon table has a glass top and a carriage-mounted light source for backlighting, making it useful mainly with the transparent type of manuscripts; the TSC was designed specifically for such material. A great many operations make use of opaque cartographic material to which the transmissive concept of signal detection would not be applicable, since the amount of light transmitted would not be adequate. Thus, to extend the aided-track concepts established by the TSC to opaque materials would require a different approach in illuminating the manuscript.

The objectives of the investigations carried out under this present contract were aimed at:

(1) Determining a suitable source of illumination for opaque material. The source, to be an integral part of the cursor, should provide adequate feature detection levels for a representative sampling of cartographic charts having dark feature lines, easily controlled uniformity, and minimum heat dissipation within the cursor.

(2) Defining and investigating those problem areas peculiar to operation of the scanning cursor on opaque materials, such as level differences due to background color, spatial noise introduced by half-tone color processing, and spectral response changes due to absorption effects of the incident illumination on multicolored printed material.

The approaches taken to meet these objectives are described in Section II. Implementation of the Reflective Scanning Cursor (RSC) using the TSC cursor design and electronic processing circuitry is also discussed.

Section II

IMPLEMENTATION OF THE REFLECTIVE SCANNING CURSOR CONCEPT

A. ILLUMINATING SOURCE CHARACTERISTICS

A source of illumination for opaque material is required having the following physical and photometric characteristics:

(1) A 1-inch diameter circle is to be illuminated by a source or combination of sources. The uniformity of illumination is of primary importance only in a 1/8- to 1/4-inch diameter area at the center of the circle. Elsewhere, the illumination should be such that printed matter typically displayed on cartographic charts can be easily read. Based on array dark noise and the dynamic range of the array, the degree of uniformity required in the central area is in the order of $\pm$ 2% to $\pm$ 5%.

(2) The source or sources are to be located out of the field of view of the 1-inch diameter circle as it is viewed normal to its plane. This is to minimize distraction and/or to minimize obscuring of the printed or graphic material within the viewing circle.

(3) The radiant/photometric characteristic of the source is to be such that, when working with the optical system of the Transmissive Scanning Cursor (TSC) and the linear photosensitive array, reflective differences between representative backgrounds and dark feature lines will be adequate to permit error-free detection of the feature at tracing speeds up to 2 inches per second.

(4) Line widths to be detected range from 4 to 20 mils.

The basic optical configuration for a Reflective Scanning Cursor (RSC) is shown in Fig. 1. Except for the illumination source shown, the optical system is identical with that developed for the TSC.

B. ILLUMINATION SOURCES

Prospective means of illuminating opaque manuscript materials investigated were:

(1) Visible illumination sources using filament lamps incorporated within the cursor.

(2) IR illumination using a ring of light emitting diodes (LEDs) with their optical axes directed toward a center point on the manuscript.

(3) Visible illumination using fiber optic light pipes, the source being externally located outside of the cursor body.

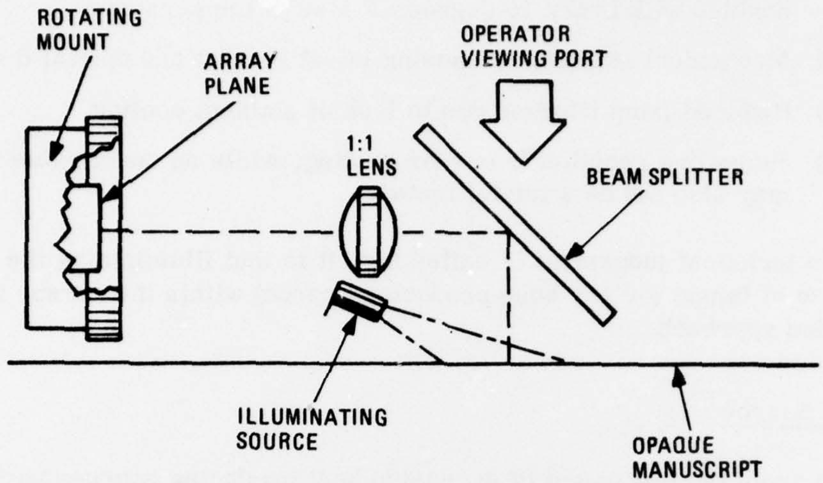


Fig. 1. Basic optical configuration for a reflective scanning cursor.

1. Filament Lamp Source

Initial attempts to provide internal illumination made use of miniature filament lamps. Tests were performed with a Chicago Miniature No. 253 bulb, having a lens end cap. These lamps are a good source of infrared (IR) radiation and find use in encoders, card readers, and tape readers. The lamp is rated for 2.5V at 350 mA, with a 10,000 hour lifetime. The spot produced by the lens on a surface normal to the lamp axis is elliptical, and is severely shaded when not used at its specified working distance. While the center area of the spot is of high intensity at a distance of 0.375 inch from the tip, drastic variations occur as the lamp is positioned axially away from the surface, becoming an area of lower intensity. A combination of two overlapping spots was required to achieve a usable uniformity when the lamps were aimed angularly at the center of the area of interest at a distance of 0.5 inch. While adequate illumination could be obtained for ample signal discrimination, the manipulations and adjustments required to obtain reasonable uniformity would discourage use of this source. This was also found to be the case for miniature lamps without lens ends. A much more severe problem, however, overshadows this disadvantage. Even at reduced ratings, the heat generated by the lamp would eventually be conducted throughout the entire cursor housing. The lamps operate essentially in a closed cavity bounded by the cursor walls, the beam splitter, the plexiglass reticle, and the housing of the cursor. Heat remains trapped within this cavity, and no efficient means is obvious for removing it without jeopardizing the cursor design. The effects of heating on system operation are somewhat difficult to predict, since equilibrium conditions would have to be determined. We can, however, indicate some possible effects that would have to be considered:

(1) Electrical effects on the array caused by temperature rise. For back-biased operation, for example, planar diffused silicon photodiodes show a

response variation of 0.07% per degree F, while dark leakage current doubles with every 10 degrees F rise in temperature.

(2) Mechanical expansion, causing misalignment and optical displacements.

(3) Reduced lamp lifetime due to lack of ambient cooling.

(4) Subjective reaction to cursor heating, while an undefinable factor, may also not be a trivial factor.

If a technical judgement is called for, it is that illuminating the manuscript by direct use of lamps (or any heat-producing source) within the cursor is not a recommended approach.

2. IR Source

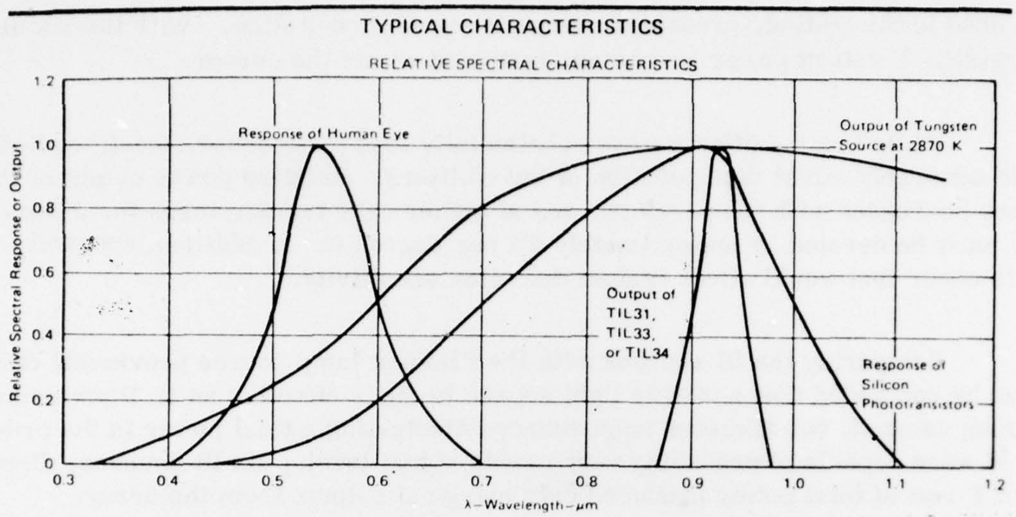
To avoid the placement of excessive heat producing sources within the cursor, attention was given to illuminating the manuscript using lower power IR sources. (This does not completely solve the heating problem, since a visible source must be included to allow the operator to view the manuscript. However, this background lighting can be much subdued in intensity, and a much lower dissipation will be encountered).

Since the silicon elements of the array show a peak response in the IR region, the IR source would be well-matched to this characteristic. Chosen for these tests was the Texas Instruments Type TIL 31 GaAs light emitting diodes (LEDs) packaged in a TO-18 case. These units dissipate 150 mW (1.5V @ 100 mA) with a typical radiant intensity of 250 milliwatts per steradian*; peak emission is at a wavelength of 0.94 μm. Figure 2 shows the spectral characteristics of the TIL 31 and of the human eye. The TIL 31 has no output in the visible spectrum.

An insert was machined for installing up to six emitters axially directed toward the manuscript center. Figure 3 shows the installation of the LEDs in the cursor prior to wiring. As with the lens-end filament lamps, a difficult alignment procedure, compounded by the fact that the radiance patterns are not visible, had to be followed. The alignment was performed by maximizing the array output observed on a CRO as the individual IR emitters were adjusted.

The units were operated at a nominal forward current of 100 mA, for a specified radiant power output of 6 mW. It was found that in order to produce usable signal levels, a number of emitters would be required; a maximum of six TIL 31s

*Radiometric measurements indicated that for the best units the radiance was only 30 to 40 milliwatts per steradian.



(Source: TI Data Sheet)

Fig. 2. Spectral characteristics of the TIL31 IR emitter.

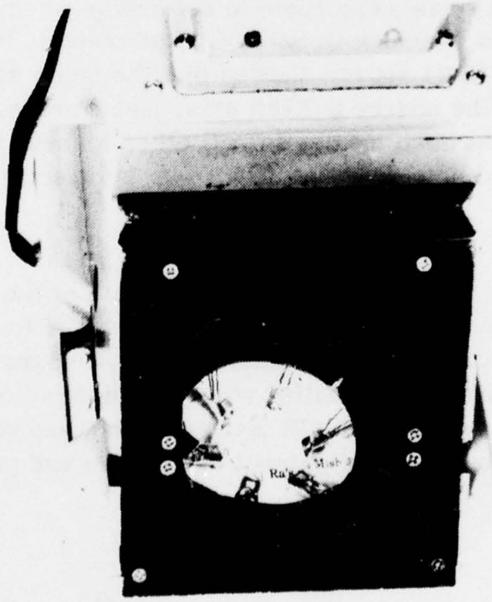


Fig. 3. View of cursor with the beam splitter removed, showing the insert with LEDs installed prior to wiring. (Six units are arranged to illuminate the center area of the viewing circle. This insert was also used as a mount to test filament lamps as illumination sources.)

was used in the testing, producing marginal signal modultation. With the six units energized, 1 watt of power was being dissipated within the cursor.

While heating effects were substantially less pronounced, localized heating could adversely affect the operation of the emitters. Relative power output of the device decreases with temperature, and at higher case temperatures the device current must be derated by approximately 2% per degree C. In addition, spectral shifts occur that would affect system detection sensitivity.

Comparing the IR sources with the filament lamp source previously discussed, it can be concluded that a visible light source is more effective as an illuminator. Running derated, two filament lamp sources dissipating a total power in the order of 1.5 W were capable of producing very usable signal levels; six IR sources, dissipating about 1 watt of total power produced only marginal outputs from the array.

Possible explanations for the reduced IR outputs would lie in the difficulty of optimally aligning the sources, in the spectral response of the optical components, and in the contrast ratio of the imaged lines in the IR regions.

The cursor uses a mirror-type beam splitter with a neutral color interference coating. Subsequent tests were made to determine whether the beam splitter did, in fact, limit IR from reaching the array. Radiometric bench measurements using the beam splitter and a TIL 31 source showed that the beam splitter transmitted 70% of the IR when normal to the source pattern axis, and increased to 90% transmission when tilted 45 degrees. At best, neglecting all other losses, only 10% of IR incident on the beam splitter would be reflected. The beam splitter is essentially transparent to IR.

This bandwidth limitation in the reflective path of the existing beam splitter makes the response measurements of the reflective cursor to IR-illuminated manuscripts inconclusive. However, the consideration of IR sources as illumination devices still presents the problem of dealing with heat dissipation within the unit. As in the case of the filament source, the IR source did not appear to be a viable means for manuscript illumination due to alignment difficulties and possible degradation of the array output with long-term heating.

3. Fiber Optics

Because of the severity of the heating problems likely to be encountered in incorporating sources directly in the cursor unit, attention was given to the use of an external source of illumination, using fiber optics to transmit the light to the cursor.

Tests were conducted with 1/16- and 1/8-inch diameter bundles routed into the cursor viewing area. The source, a 21-volt tungsten-halogen filament lamp, was remotely located 4 feet away. At rated voltage, the lamp operates at a color temperature of 3350^{o}K.

The optical and physical properties of a typical 1/8-inch diameter fiber optic bundle are given in Table 1, with the spectral transmission characteristics shown in Fig. 4.

Illumination patterns emitted from the output ends of the bundles are directive, being defined by the numerical aperture, and were fairly well diffused; shading was influenced primarily by the distance from the area to be illuminated. Greater uniformity was obtained by addition of vellum diffusers, but as subsequent tests showed, these are not a requirement for this application. Sufficient field uniformity was realized by the use of two bundles angularly displaced by 120 degrees, properly adjusted in distance from the central area of illumination.

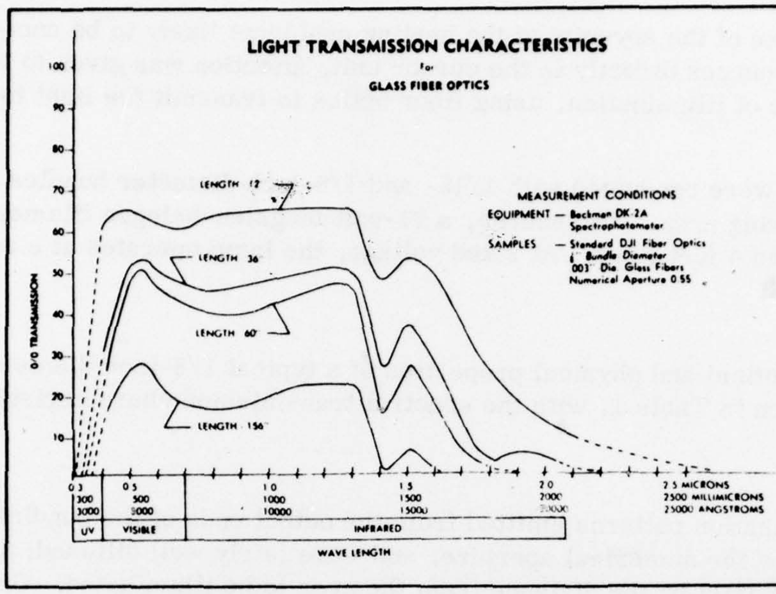
TABLE 1. CHARACTERISTICS OF TYPICAL OPTICAL GLASS FIBER TRANSMITTERS

Optical Properties

Attenuation	8% per foot
Spectral Transmission	0.4 to 2 microus
Numerical Aperture	0.55
Acceptance Cone	60 degrees

Physical Properties for 1/8-inch Diameter Bundle

Bundle Diameter	0.125 in.
Fiber Diameter	0.003 in.
Number of Fibers	1470
Minimum bending radius	0.75 in.
Packing Factor (nominal)	83%



(Source: Dolan-Jenner Industries Bulletin)

Fig. 4. Fiber optic spectral transmission characteristics.

Fiber optic illumination seems an ideal choice, avoiding the heating problem while providing a controllable high intensity light of good uniformity and ample illumination, which is relatively insensitive to small pointing angle variations and does not require auxiliary optics.

Figure 5 shows the installation of the fiber optic bundles within the cursor. For convenience, the bundles enter through holes drilled through the cursor body, directed toward the center of the viewing area.

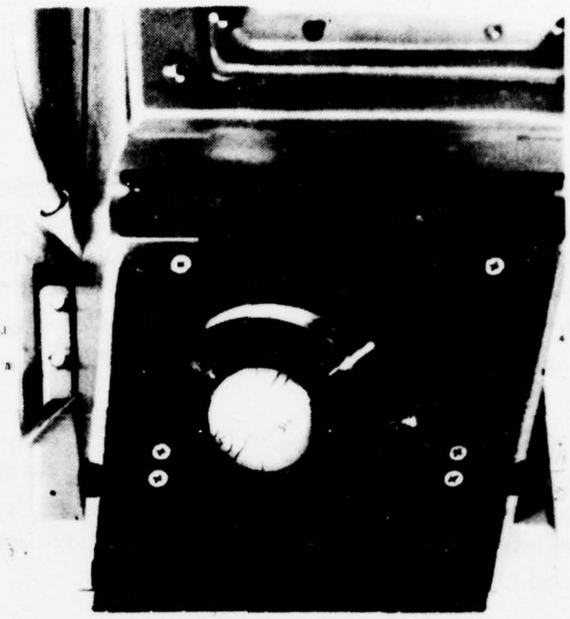


Fig. 5. Manuscript illumination using fiber optic bundles. (The bundles, shown entering the cursor on each side, are directed toward the center of the viewing circle. The beam splitter used in the optical path is removed in this view to show the fiber optic arrangement.)

Section III

REFLECTIVE SCANNING CURSOR

A. PRELIMINARY TESTS

Preliminary tests using fiber optic illumination were carried out on photographic lines against a white background. Trials were made with two sets of fiber optics, one set being 1/8-inch diameter, the second 1/16-inch diameter. For both cases, the irradiance at the manuscript surface was measured to be in the order of 0.5 milliwatt per square cm, which is roughly equivalent to the illumination resulting from a high intensity lamp on a surface 8 to 10 inches away.

The upper trace of Fig. 6 shows the dark level output from the sample-and-hold (S/H) amplifier following the array, prior to smoothing. (The S/H amplifier has unity gain). The square-wave noise is the result of line unbalance in the array drive circuits.* A 30 millivolt level shift is shown due to differences between the two clock phases used to drive the array.

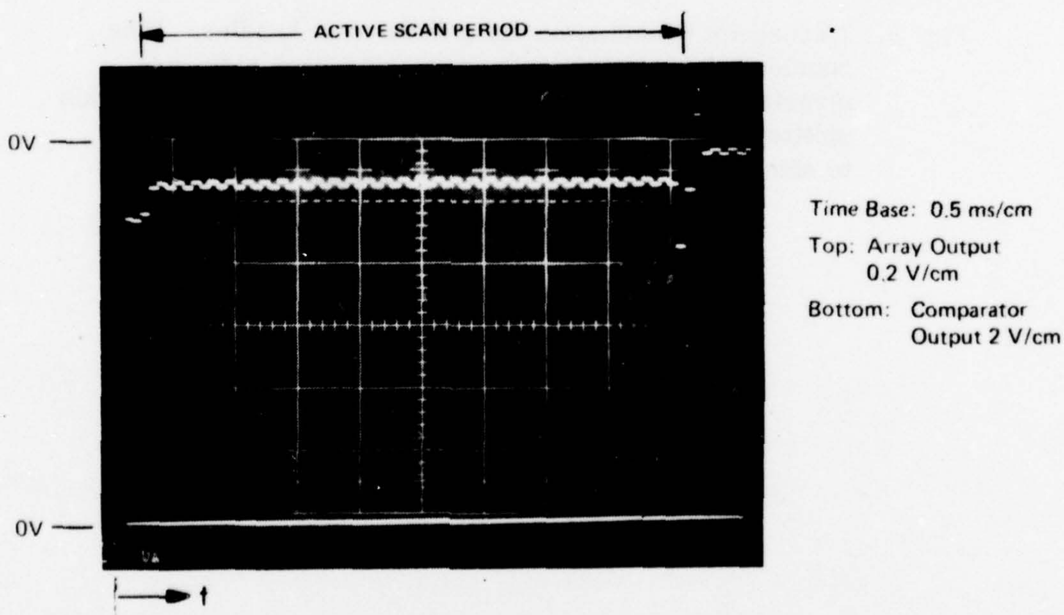


Fig. 6. Dark level array output.

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*Newer versions of the array contain the phase drivers on the same chip and do not display this unbalance phenomenon.

The bottom trace of the following waveform photographs represents the TTL-compatible signal detection gate generated by amplifying and thresholding the S/H output. * For all tests shown here, an array scan rate of 132 scans per second was used; with a 14 KHz sampling clock.

Figure 7 shows the output level of the array for a set of 1/8-inch diameter fiber optic illuminators with diffusers on the output end. The high uniformity achievable can be demonstrated here. The small "glitches" in the array output are caused by detection of the aided tracking circles on the reticle used with the cursor. The bottom trace is the output gate from the digital detection circuitry.

Figure 8 shows the response of the array to a 7-mil line, and the resultant gate generated from the detection. Similarly, Fig. 9 and Fig. 10 show these outputs for line widths of 12 mils and 23 mils, respectively. (In these photographs, note should be taken of time-base changes.)

Using the 1/16-inch diameter fiber optic bundles, the output intensity was reduced by the diffusers and these were removed for further testing. The degree of uniformity of the illumination without diffusers is evident in Fig. 11. Following, Fig. 12, 13, and 14 show the outputs for detected line widths of 7, 12, and 23 mils, respectively.

The significance of these preliminary tests is that they establish a baseline indicating the achievable uniformity for the fiber optic sources with and without diffuser elements, and establish the principle of operating the cursor in a reflective mode.

On the basis of these tests, 1/8-inch diameter fiber optic bundles were selected for use, leaving the option of using diffusers for obtaining greater uniformity if required on other material.

B. OPAQUE CARTOGRAPHIC MANUSCRIPTS (EFFECTS OF BACKGROUND COLOR ON ARRAY OUTPUT.)

The manner in which the array output varies with respect to background color and shading on a representative hydrographic chart is shown in Fig. 15. This is a superimposed trace of one scan of the smoothed array output (a smoothing time constant of 6 milliseconds follows the sample-and-hold output) for white, blue, and gray backgrounds, identified as (a), (b), and (c), respectively. Trace (a) of the white background contains only the residual noise due to the unbalance of the array drive phases.

*Detailed descriptions of the video processing circuitry may be found in the Final Technical Report issued under RADC Contract No. F30602-74-C-0318, "Scanning Cursor Techniques".

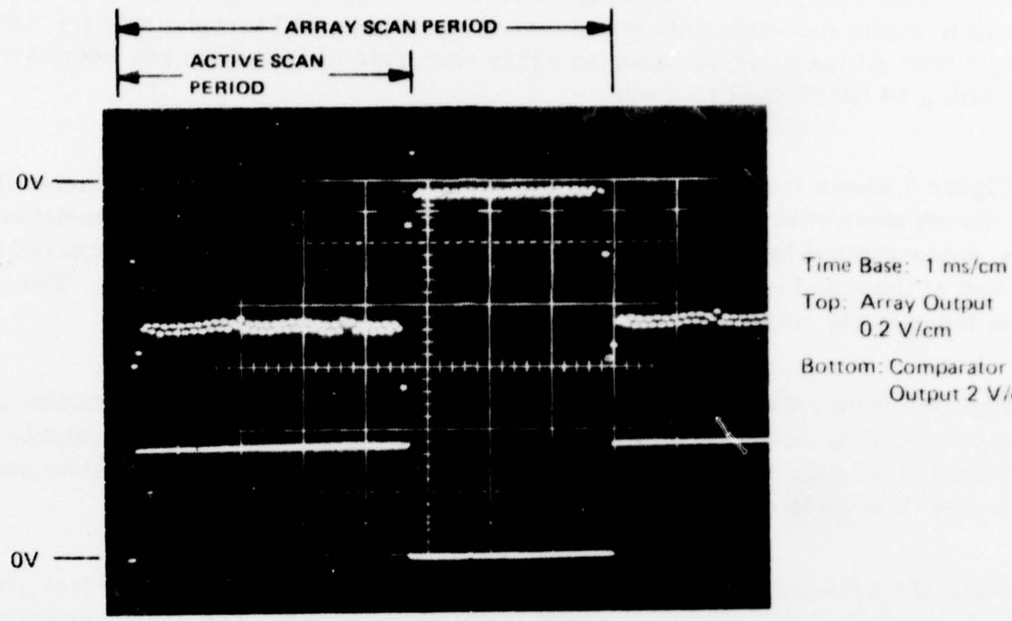


Fig. 7. Average array level for white background for 1/8-inch diameter pair of fiber optic bundles used for illumination. (Diffusers placed on output ends of the bundles. Note detection of reticle lines.)

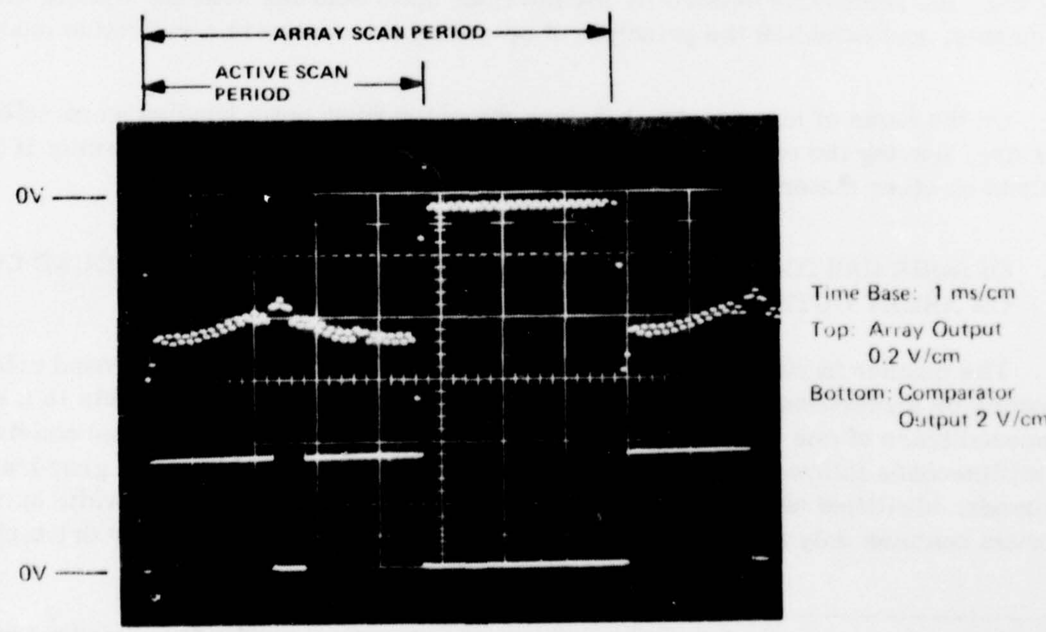


Fig. 8. Array response to 7-mil line with reflective system for 1/8-inch fiber obtics.

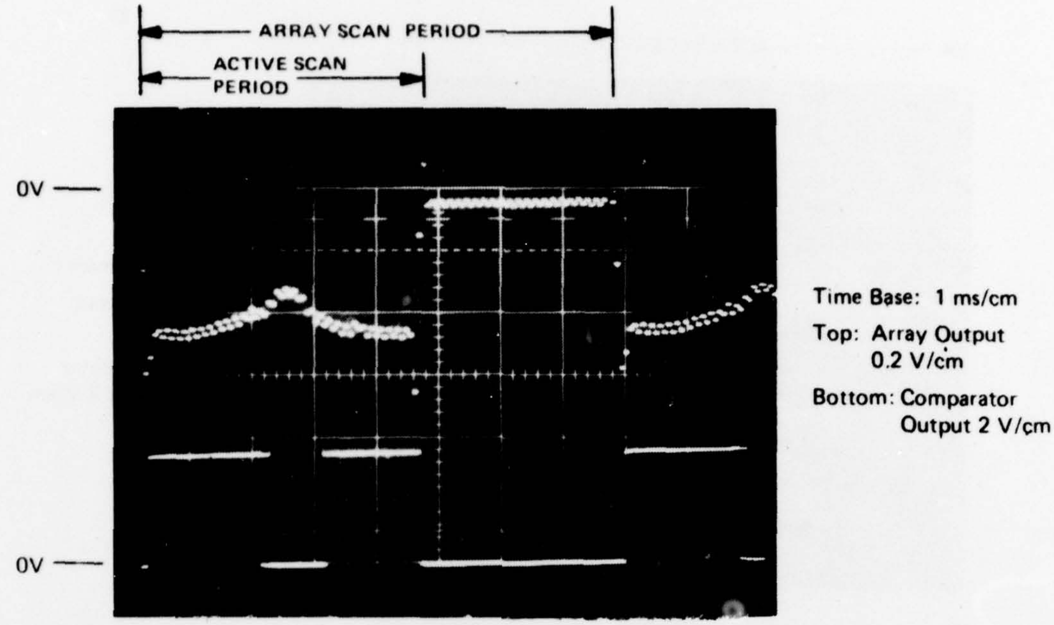


Fig. 9. *Array response to 12-mil line for 1/8-inch fiber optics.*

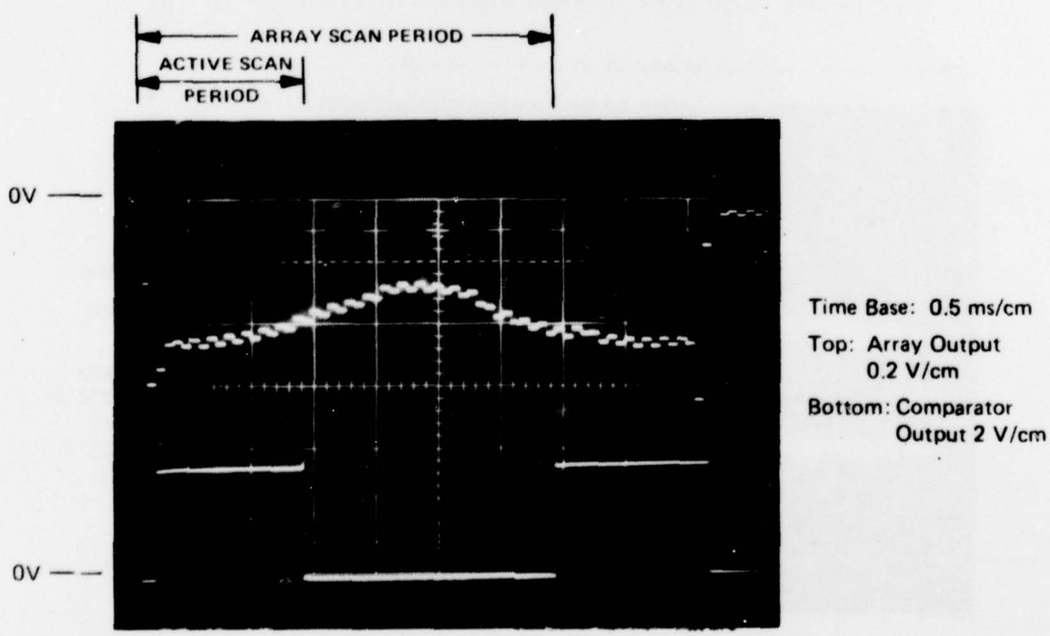


Fig. 10. Array response to 23-mil line for 1/8-inch fiber optics.

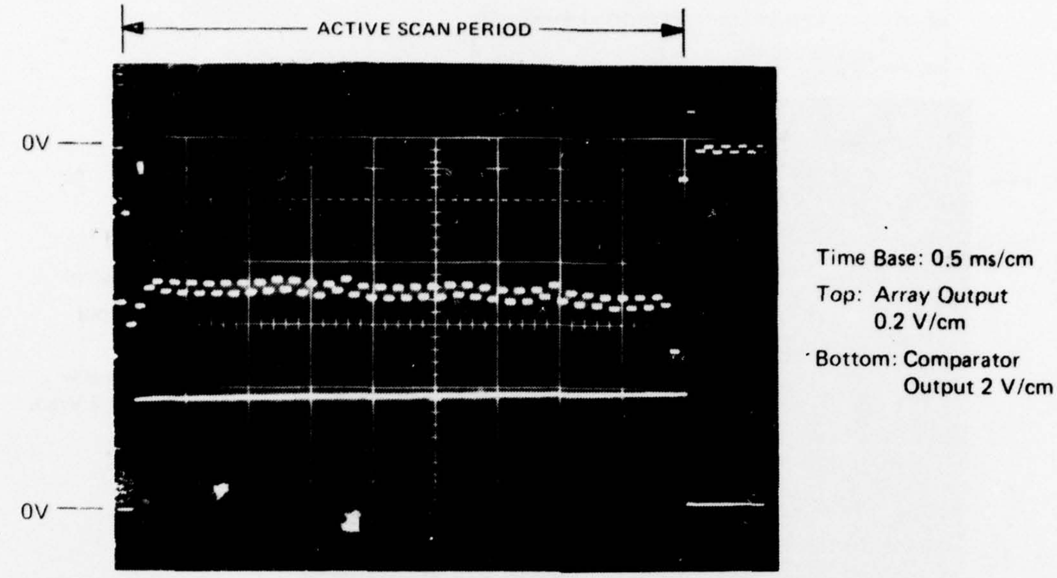


Fig. 11. Average array level for white background using pair of undiffused 1/16-inch fiber optic bundles for illumination.

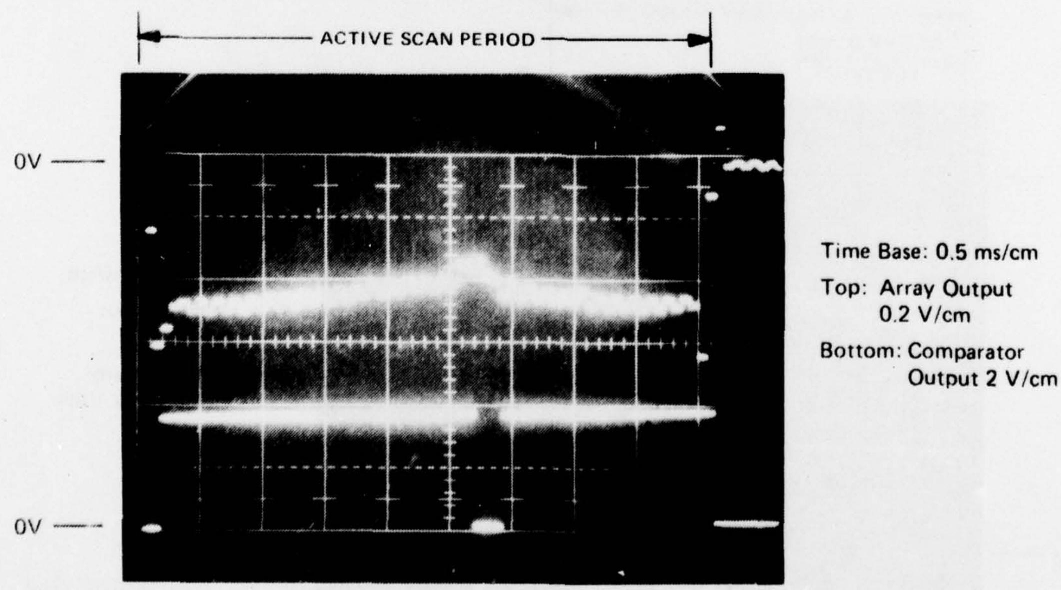


Fig. 12. Array response to 7-mil line for 1/16-inch fiber optics.

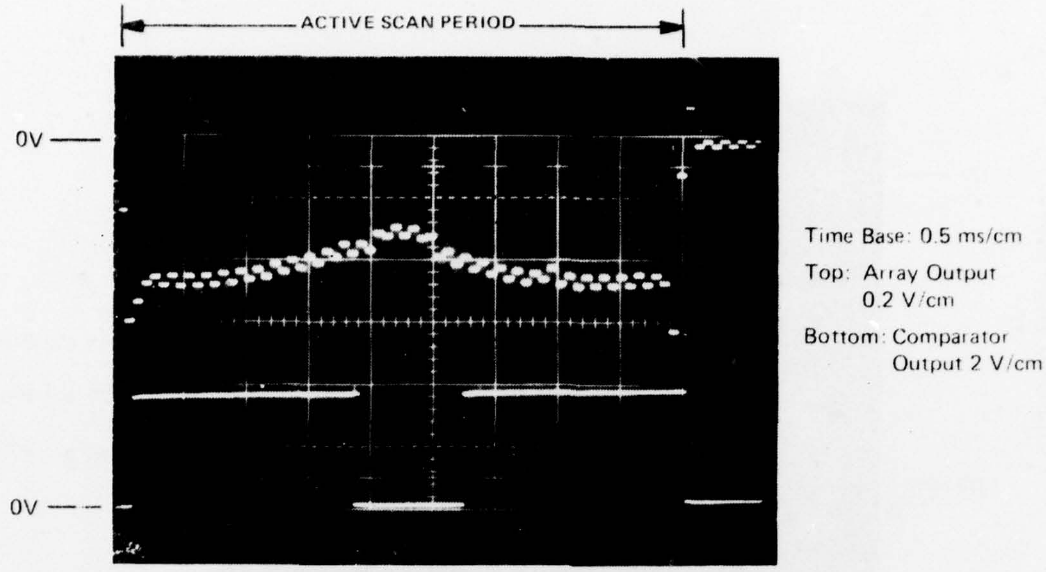


Fig. 13. Array response to 12-mil line for 1/16-inch fiber optics.

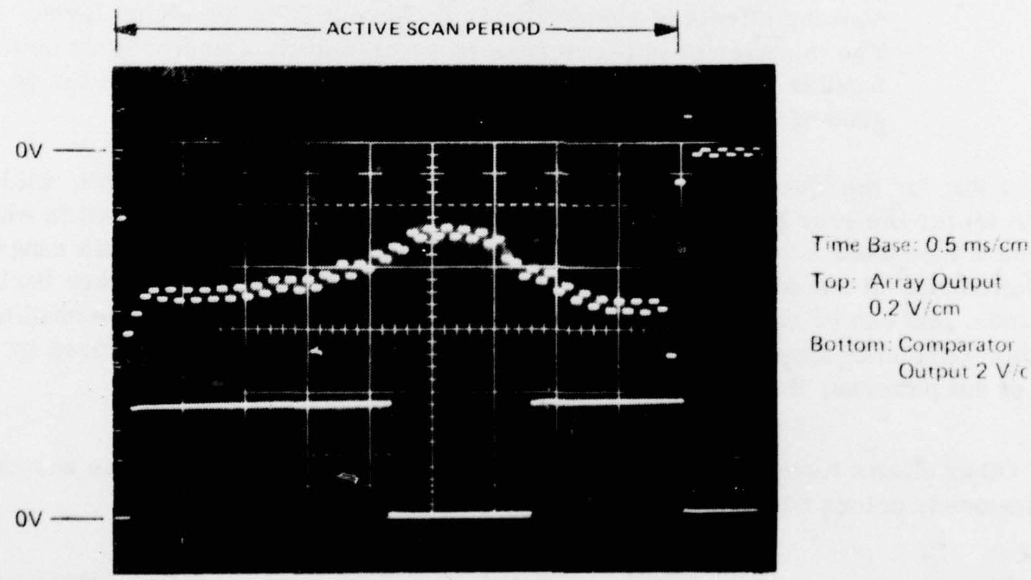


Fig. 14. Array response to 23-mil line for 1/16-inch fiber optics.

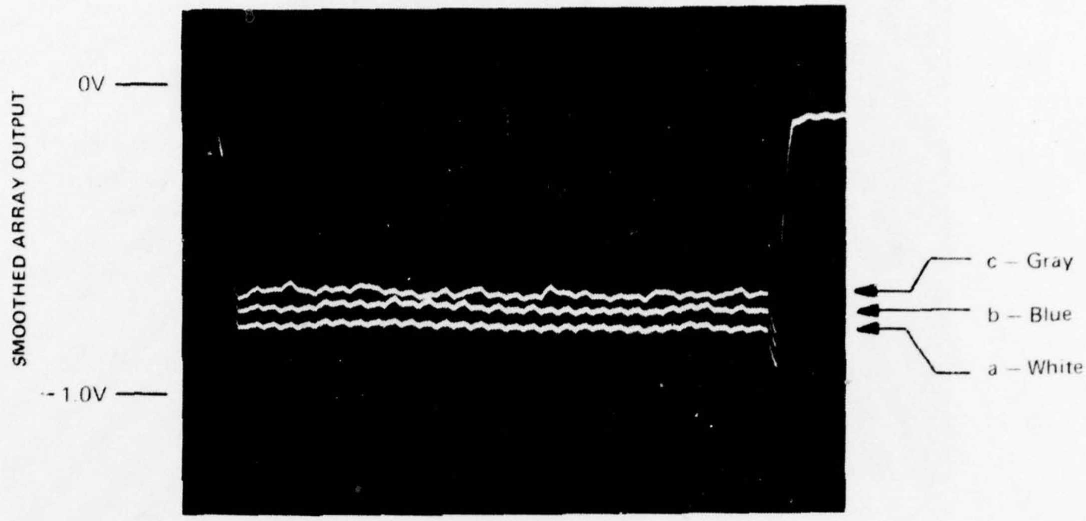


Fig. 15. Array output level vs. background color. (Smoothed array outputs showing effects of various color backgrounds on the signal level. The manuscript is illuminated by two 1/8-inch diameter fiber optic bundles located 120 degrees apart, with no diffusers. Note the degree of uniformity obtained.)

Trace (b), for the blue background is seen to decrease in level by 0.06 volt, while trace (c) for the gray background shows a decrease of 0.1 volt with respect to white. These traces show a 20% change in the array average output level over this range of backgrounds. It can also be noted that the noise level increases with darker backgrounds, and can be related to the half-tone process used in producing the shading on this particular manuscript. Examination showed that tones were produced by the use of dot patterns, the dots being 2 to 3 mils in diameter.

Other charts tested showed similar changes in level, but spatial noise was not as pronounced, colors being of a more solid nature.

The array output is amplified by a dc-coupled, high-gain amplifier, which is balanced to bring detected lines into the linear range of the device. Variations in the background level changes the balance conditions required for signal amplification. Line detection tests at the various color boundaries indicated that rebalancing is necessary if the full range of color combinations is to be covered.

Section IV

DEVELOPMENT OF THE AUTOMATIC BALANCE AMPLIFIER

In the preceding section, the change in array output level with background color was shown. This limits the line detection capability because of required changes in the balance voltage as the detected signal peak-to-background average varies.

A study was undertaken to determine parameter values for all color boundary conditions for which a positive signal detection could be made on a typical 5-mil boundary feature. For each condition, the balance voltage was varied to optimize the detected signal at the amplifier output, and the balance voltage and average amplifier output voltage recorded. This quickly led to the realization that if the average level were measured for a condition of positive feature detection, and this level was then maintained for all other boundary conditions, we would expect the amplifier to exhibit identical output waveforms, assuming that an ample signal-to-noise ratio is present.

The concept of an automatic-balancing amplifier performing this function was carried through to the design and construction stages.

A block diagram of the amplifier is shown in Fig. 16. The balance amplifier output is put through a low-pass filter acting as an averaging circuit. The averaged output is compared to a reference voltage; the difference voltage is used to rebalance the amplifier under changing input conditions for the average output voltage to be equal to the reference. Thus, if the reference voltage is established for the condition of lowest signal-to-noise ratio that results in a positive, unambiguous signal detection, the balance amplifier will attempt to maintain the same waveform for all other conditions. The self-balancing feature also provides a tolerance range to variations in illumination source brightness.

A schematic diagram of the constructed automatic balance amplifier is shown in Fig. 17. The amplifier, Z12, is the existing balance amplifier in the video processor; the manual-automatic switch was provided to permit switching between the two modes to compare the amplifier output under differing input conditions.

This automatic balance amplifier performed well with all available manuscripts, and proved effective in detecting dark feature lines and pencilled markings of various colors.

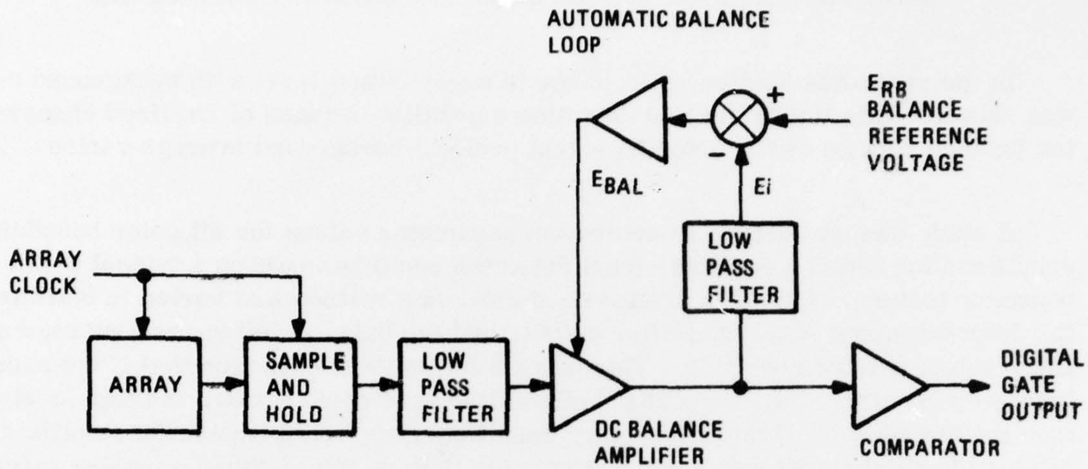


Fig. 16. Block diagram of analog array signal processing to adjust dc balance in response to changes in manuscript background level.

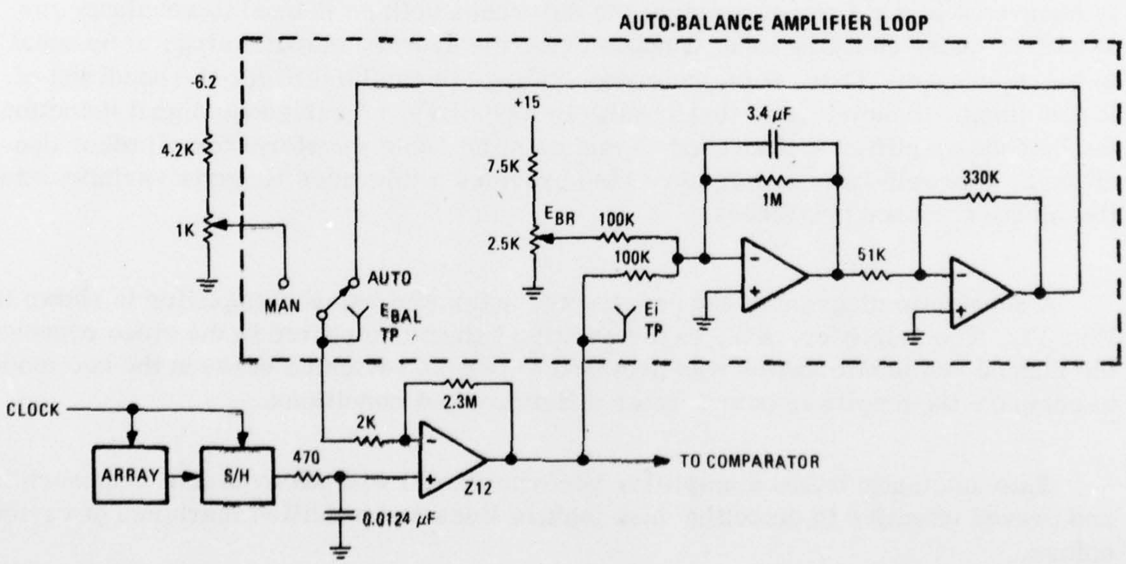


Fig. 17. Schematic diagram of the automatic balancing array signal amplifier. (The outlined portion of the circuit generates a self-adjusting balance voltage by comparing the average output of amplifier Z12 with a reference voltage, E_{BR}.)

Photographs for four color boundary transition cases are shown in Fig. 18. The smoothed array output is shown in the upper traces for (a), a 5-mil line at a blue-white boundary transition; (b), a 5-mil line at a blue-gray boundary transition; (c), a 5-mil line on a gray background; and (d), a 2-mil line at a gray-white transition. The resultant balance voltages during the scan interval are shown in the center traces, and the balance amplifier output voltages in the bottom traces. These amplifier output voltages are put through a comparator with a zero-level threshold to generate a TTL compatible gate used in the digital counter logic. Note that each detected line at the amplifier output is of equal width to maintain a constant average over the scan interval, while for the 2-mil line the detection is somewhat narrower to accommodate the noise contribution in the average. The line width is of no significance, since following digital logic circuits process the output of the video processor to represent the center of the detected feature, regardless of width.

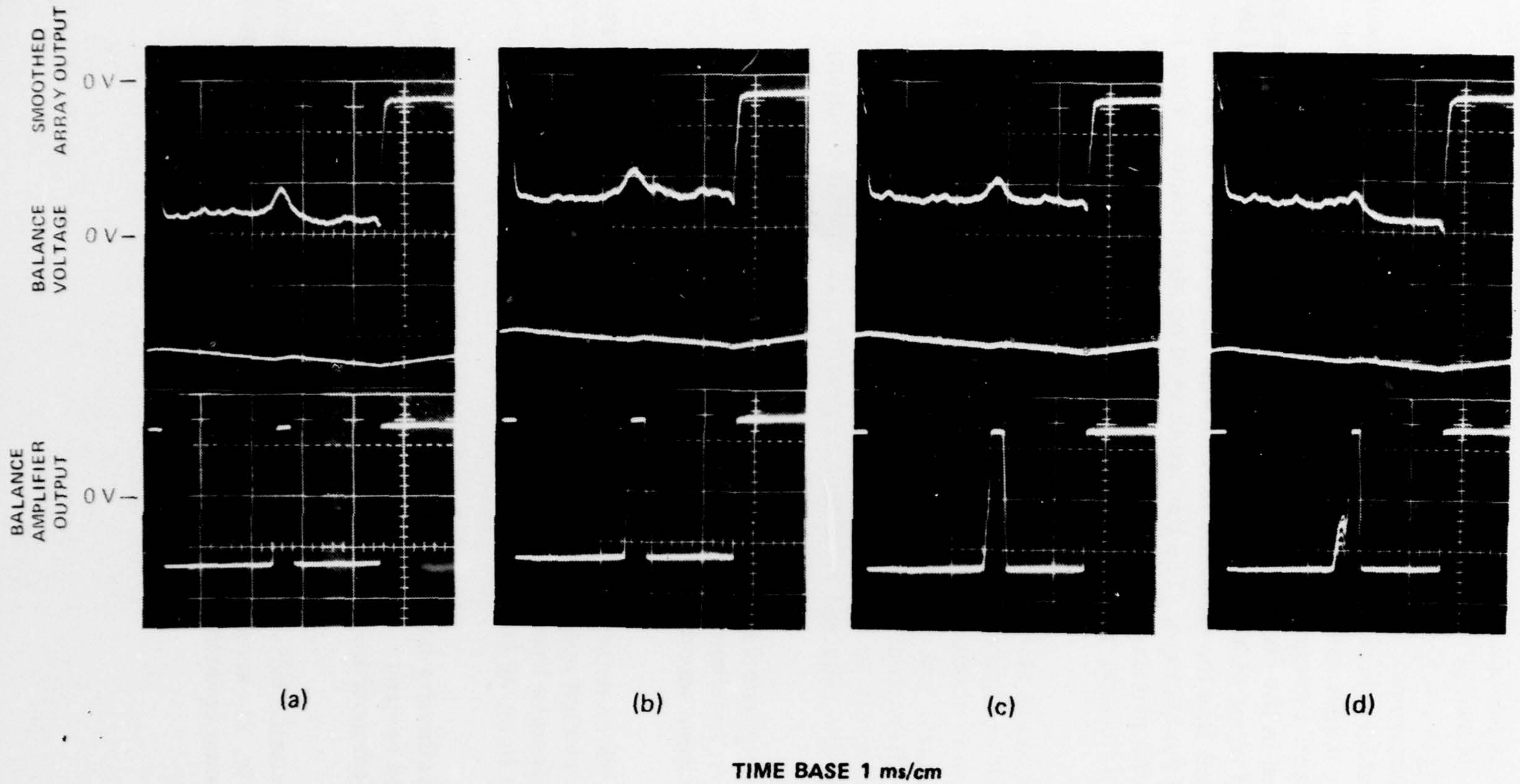
Figure 19 shows the array response to colored pencil lines; the bottom trace is the output of the threshold comparator following the balance amplifier. As can be seen, negligible response is obtained for red. Similar tests were made using ball-point pens, and the responses are shown in Fig. 20 for black, blue, and red inks. Here again, the greatly attenuated red response is quite evident. Line widths for these tests were approximately 20 mils. (Manual balancing for the amplifier was used in these tests; the brown line required rebalance to provide a comparator output).

As noted earlier, the particular beam splitter used in the optical system may be poorly matched to the red spectrum; consequently, very little is contributed to signal modulation from these wavelengths in the reflective path to the array.

The mechanism by which detection of colored features is possible is the absorption of portions of the irradiant spectrum. A lower amount of energy is then reflected from the surface of the feature line compared to the lighter background, and is indicated by the reduction in array response when the feature is focussed onto the array.

By increasing the reflective bandwidth through means of special coatings on the beam splitter, improved response can be obtained in the red region for detection of colors having spectral components extending into this range.

Typical coatings suitable for varying the reflectance characteristics of the beam splitter are shown in Fig. 21; specifications for the coating in this application would call for partial reflectance covering the visible and near-IR wavelengths.



Scale Factors:
Top Trace: 0.5 V/cm
Center Trace: 0.5 V/cm
Bottom Trace: 10 V/cm

Fig. 18. Waveforms showing behavior of automatic balancing amplifier in detecting feature lines separating various colored areas on typical cartographic manuscript. [Top waveform shows the smoothed array output, the center indicates the balance voltage generated during the scan cycle, and the bottom trace shows the output of the balance amplifier. A 5-mil feature detection for a blue-to-white transition is shown in (a), blue-to-gray in (b), and against a gray background in (c). A gray-to-white transition is shown in (d) with a 2-mil feature detection.]

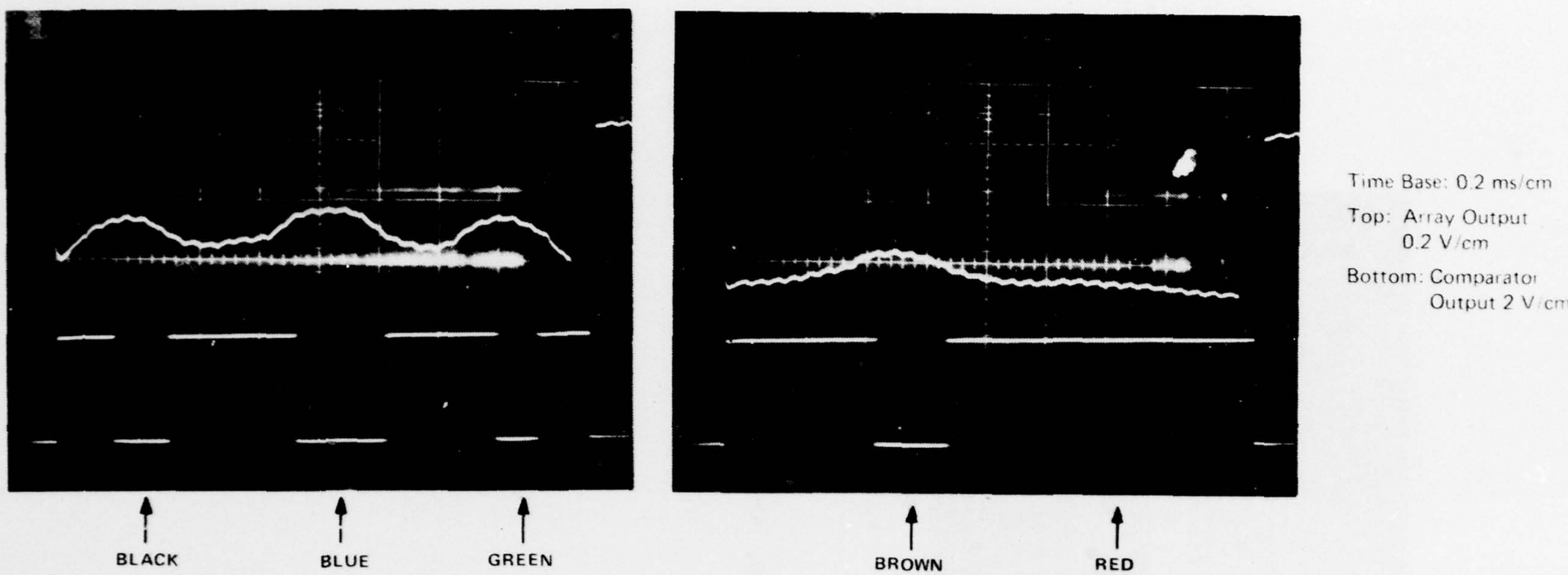


Fig. 19. Array response to colored pencil lines.

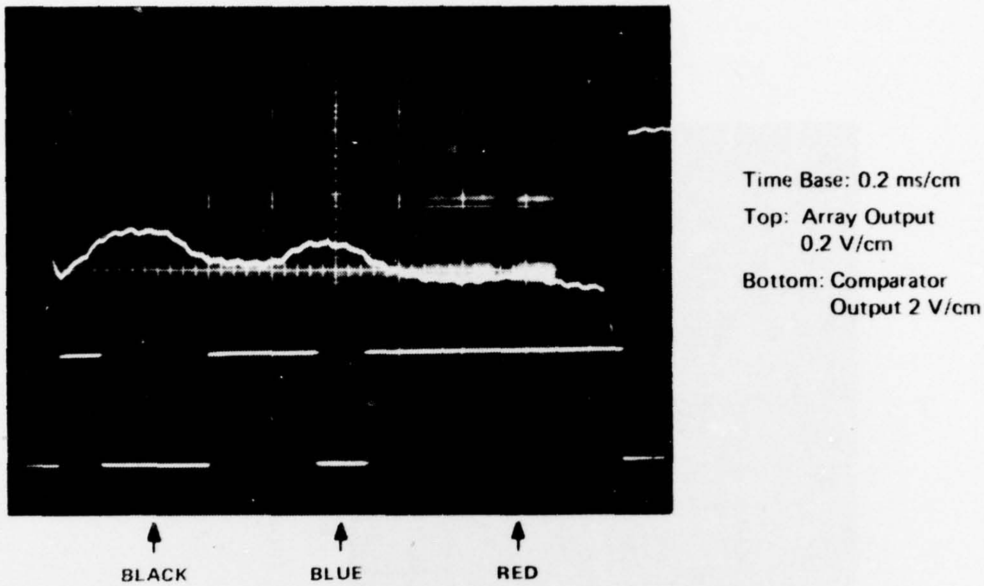
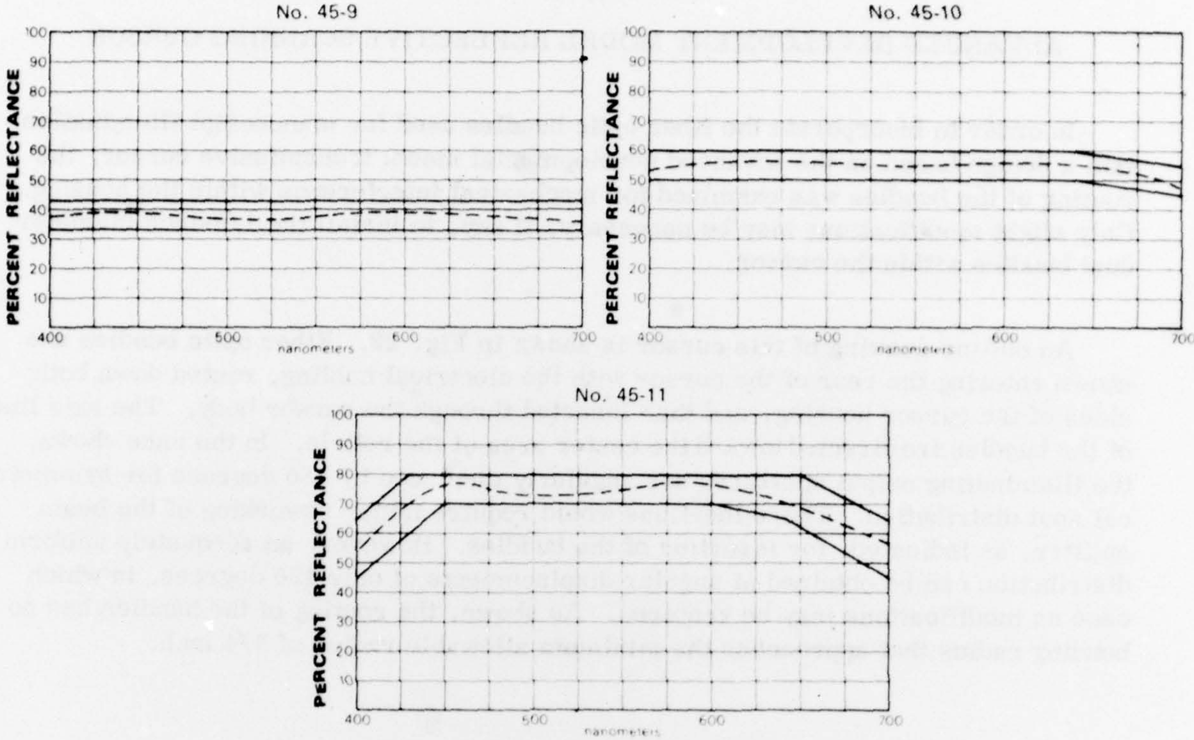


Fig. 20. Array response to ball-point pen lines.



45-9 Plate Beamsplitter 35/65
45-10 Plate Beamsplitter 55/45
45-11 Plate Beamsplitter 75/25

These beamsplitter coatings are essentially non-selective with respect to wavelength over the visible spectrum, and appear practically neutral. They are designed for an angle of incidence of 45°.

There are three plate beamsplitter coatings offered to provide the designer with a choice in the ratio of the intensity of the light reflected to that transmitted as may be required in different optical problems. The nominal values of these reflectance/transmittance ratios are 35/65, 55/45, and 75/25.

As with other Multi-Film coatings there is virtually no loss of light by absorption in these beamsplitters, the sum of the reflected and transmitted intensities being equal to the intensity of the incident beam.

(Source: Herron Optical)

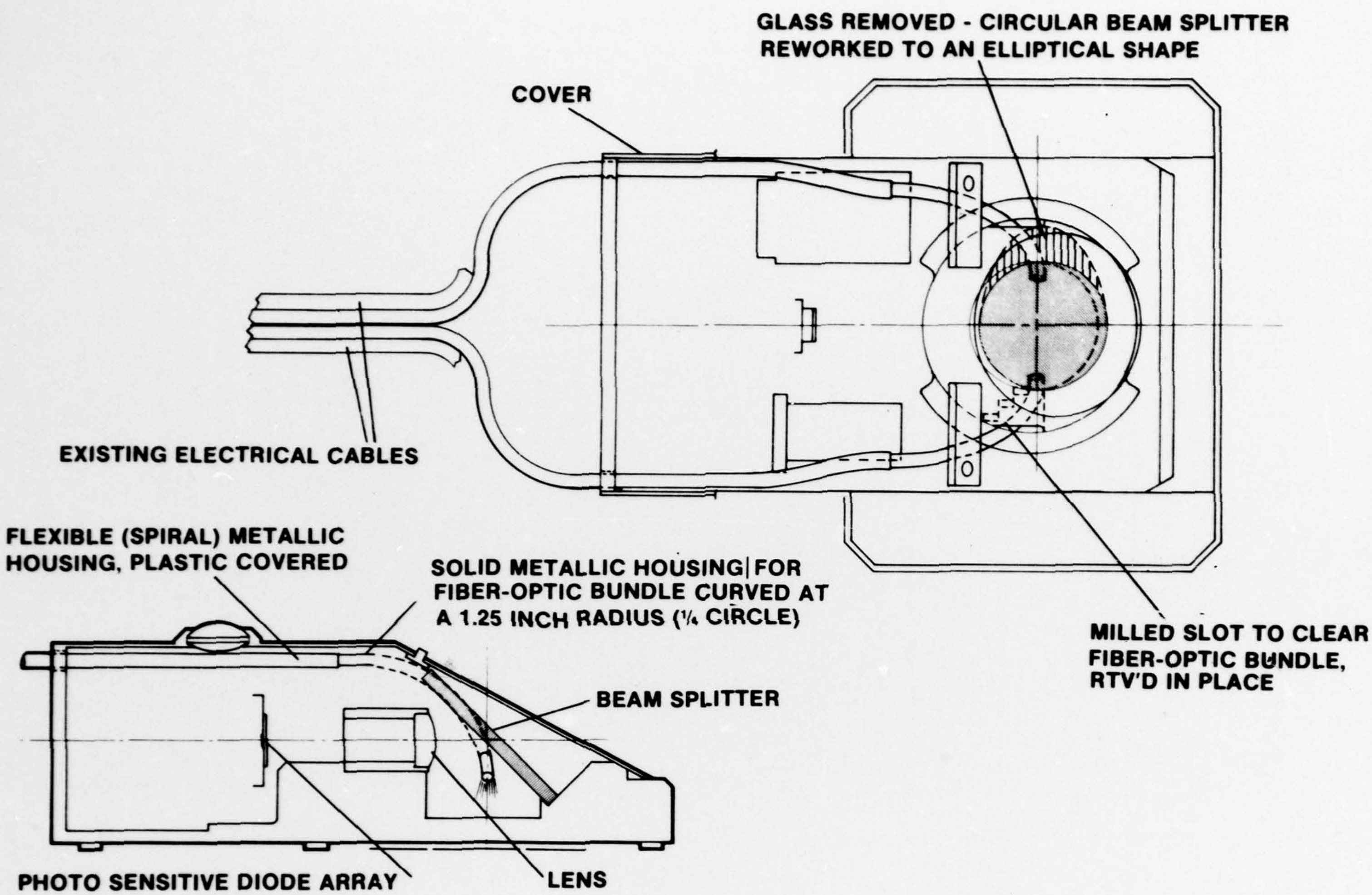
Fig. 21. Typical characteristics for neutral beamsplitters.

Section V

ADVANCED DEVELOPMENT MODEL REFLECTIVE SCANNING CURSOR

In order to incorporate the fiber optic bundles used for manuscript illumination into a design based on the advanced developmental model transmissive cursor, the routing of the bundles was examined for mechanical interference within the housing. Only slight modifications may be necessary, if any, to install the 1/8-inch diameter dual bundles within the cursor.

An outline drawing of this cursor is shown in Fig. 22. Fiber optic bundles are shown entering the rear of the cursor with the electrical cabling, routed down both sides of the cursor housing, and then inserted through the cursor body. The axis lines of the bundles are directed toward the center area of the reticle. In the case shown, the illuminating output apertures are angularly displaced by 180 degrees for symmetrical spot distribution. These locations would require minor reworking of the beam splitter, as indicated, for insertion of the bundles. However, an adequately uniform distribution can be obtained at angular displacements of only 120 degrees, in which case no modifications may be required. As shown, the routing of the bundles has no bending radius that approaches the minimum allowable radius of 3/4 inch.



SIDE VIEW

Fig. 22. One configuration for routing fiber optic illuminating bundles in a cursor based on the transmissive model design. (Bundles shown are located 180 degrees apart in this example, requiring the minor modifications indicated.)

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